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THE REFLEX ARC CONCEPT IN PSYCHOLOGY.

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That the greater demand for a unifying principle and controlling working hypothesis in psychology should come at just the time when all generalizations and classifications are most questioned and questionable is natural enough. It is the very cumulation of discrete facts creating the demand for unification that also breaks down previous lines of classification. The material is too great in mass and too varied in style to fit into existing pigeon-holes, and the cabinets of science break of their own dead weight. The idea of the reflex arc has upon the whole come nearer to meeting this demand for a general working hypothesis than any other single concept. It being admitted that the sensori-motor apparatus represents both the unit of nerve structure and the type of nerve function, the image of this relationship passed over into psychology, and became an organizing principle to hold together the multiplicity of fact.

In criticising this conception it is not intended to make a plea for the principles of explanation and classification which the reflex arc idea has replaced; but, on the contrary, to urge that they are not sufficiently displaced, and that in the idea of the sensori-motor circuit, conceptions of the nature of sensation and of action derived from the nominally displaced psychology are still in control.

The older dualism between sensation and idea is repeated in the current dualism of peripheral and central structures and functions; the older dualism of body and soul finds a distinct

echo in the current dualism of stimulus and response. Instead of interpreting the character of sensation, idea and action from their place and function in the sensori-motor circuit, we still incline to interpret the latter from our preconceived and preformulated ideas of rigid distinctions between sensations, thoughts and acts. The sensory stimulus is one thing, the central activity, standing for the idea, is another thing, and the motor discharge, standing for the act proper, is a third. As a result, the reflex arc is not a comprehensive, or organic unity, but a patch-work of disjointed parts, a mechanical conjunction of unallied processes. What is needed is that the principle underlying the idea of the reflex arc as the fundamental psychical unity shall react into and determine the values of its constitutive factors. More specifically, what is wanted is that sensory stimulus, central connections and motor responses shall be viewed, not as separate and complete entities in themselves, but as divisions of labor, functioning factors, within the single concrete whole, now designated the reflex arc.

What is the reality so designated? What shall we term that which is not sensation-followed-by-idea-followed-by-movement, but which is primary; which is, as it were, the psychical organism of which sensation, idea and movement are the chief organs? Stated on the physiological side, this reality may most conveniently be termed coördination. This is the essence of the facts held together by and subsumed under the reflex arc concept. Let us take, for our example, the familiar child-candle instance. (James, *Psychology*, Vol. I, p. 25.) The ordinary interpretation would say the sensation of light is a stimulus to the grasping as a response, the burn resulting is a stimulus to withdrawing the hand as response and so on. There is, of course, no doubt that is a rough practical way of representing the process. But when we ask for its psychological adequacy, the case is quite different. Upon analysis, we find that we begin not with a sensory stimulus, but with a sensori-motor coördination, the optical-ocular, and that in a certain sense it is the movement which is primary, and the sensation which is secondary, the movement of body, head and eye muscles determining the quality of what is experienced. In other words, the real beginning is

with the act of seeing; it is looking, and not a sensation of light. The sensory quale gives the value of the act, just as the movement furnishes its mechanism and control, but both sensation and movement lie inside, not outside the act.

Now if this act, the seeing, stimulates another act, the reaching, it is because both of these acts fall within a larger coördination; because seeing and grasping have been so often bound together to reinforce each other, to help each other out, that each may be considered practically a subordinate member of a bigger coördination. More specifically, the ability of the hand to do its work will depend, either directly or indirectly, upon its control, as well as its stimulation, by the act of vision. If the sight did not inhibit as well as excite the reaching, the latter would be purely indeterminate, it would be for anything or nothing, not for the particular object seen. The reaching, in turn, must both stimulate and control the seeing. The eye must be kept upon the candle if the arm is to do its work; let it wander and the arm takes up another task. In other words, we now have an enlarged and transformed coördination; the act is seeing no less than before, but it is now seeing-for-reaching purposes. There is still a sensori-motor circuit, one with more content or value, not a substitution of a motor response for a sensory stimulus.¹

Now take the affairs at its next stage, that in which the child gets burned. It is hardly necessary to point out again that this is also a sensori-motor coördination and not a mere sensation. It is worth while, however, to note especially the fact that it is simply the completion, or fulfillment, of the previous eye-arm-hand coördination and not an entirely new occurrence. Only because the heat-pain quale enters into the same circuit of experience with the optical-ocular and muscular quales, does the child learn from the experience and get the ability to avoid the experience in the future.

More technically stated, the so-called response is not merely *to* the stimulus; it is *into* it. The burn is the original seeing,

¹ See THE PSYCHOLOGICAL REVIEW for May, 1896, p. 253, for an excellent statement and illustration, by Messrs. Angell and Moore, of this mutuality of stimulation.

✓ the original optical-ocular experience enlarged and transformed in its value. It is no longer mere seeing; it is seeing-of-a light-that-means-pain-when-contact-occurs. The ordinary reflex arc theory proceeds upon the more or less tacit assumption that the outcome of the response is a totally new experience; that it is, say, the substitution of a burn sensation for a light sensation through the intervention of motion. The fact is that the sole meaning of the intervening movement is to maintain, reinforce or transform (as the case may be) the original quale; that we do not have the replacing of one sort of experience by another, but the development (or as it seems convenient to term it) the mediation of an experience. The seeing, in a word, remains to control the reaching, and is, in turn, interpreted by the burning.¹

✓ The discussion up to this point may be summarized by saying that the reflex arc idea, as commonly employed, is defective in that it assumes sensory stimulus and motor response as distinct psychical existences, while in reality they are always inside a coördination and have their significance purely from the part played in maintaining or reconstituting the coördination; and (secondly) in assuming that the quale of experience which precedes the 'motor' phase and that which succeeds it are two different states, instead of the last being always the first reconstituted, the motor phase coming in only for the sake of such mediation. The result is that the reflex arc idea leaves us with a disjointed psychology, whether viewed from the standpoint of development in the individual or in the race, or from that of the analysis of the mature consciousness. As to the former, in its failure to see that the arc of which it talks is virtually a circuit, a continual reconstitution, it breaks continuity and leaves us nothing but a series of jerks, the origin of each jerk to be sought outside the process of experience itself, in either an external pressure of 'environment,' or else in an unaccountable spontaneous variation from within the 'soul' or the 'organism.'² As to the latter, failing to see the unity of activity,

¹ See, for a further statement of mediation, my *Syllabus of Ethics*, p. 15.

² It is not too much to say that the whole controversy in biology regarding the source of variation, represented by Weismann and Spencer respectively,

no matter how much it may prate of unity, it still leaves us with sensation or peripheral stimulus; idea, or central process (the equivalent of attention); and motor response, or act, as three disconnected existences, having to be somehow adjusted to each other, whether through the intervention of an extra-experimental soul, or by mechanical push and pull.

Before proceeding to a consideration of the general meaning for psychology of the summary, it may be well to give another descriptive analysis, as the value of the statement depends entirely upon the universality of its range of application. For such an instance we may conveniently take Baldwin's analysis of the reactive consciousness. In this there are, he says (*Feeling and Will*, p. 60), "three elements corresponding to the three elements of the nervous arc. First, the receiving consciousness, the stimulus—say a loud, unexpected sound; second, the attention involuntarily drawn, the registering element; and, third, the muscular reaction following upon the sound—say flight from fancied danger." Now, in the first place, such an analysis is incomplete; it ignores the status prior to hearing the sound. Of course, if this status is irrelevant to what happens afterwards, such ignoring is quite legitimate. But is it irrelevant either to the quantity or the quality of the stimulus?

If one is reading a book, if one is hunting, if one is watching in a dark place on a lonely night, if one is performing a chemical experiment, in each case, the noise has a very different psychical value; it is a different experience. In any case, what proceeds the 'stimulus' is a whole act, a sensori-motor coördination. What is more to the point, the 'stimulus' emerges out of this coördination; it is born from it as its matrix; it represents as it were an escape from it. I might here fall back upon authority, and refer to the widely accepted sensation continuum theory, according to which the sound cannot be absolutely *ex abrupto* from the outside, but is simply a shifting arises from beginning with stimulus or response instead of with the coördination with reference to which stimulus and response are functional divisions of labor. The same may be said, on the psychological side, of the controversy between the Wundtian 'apperceptionists' and their opponents. Each has a *disjectum membrum* of the same organic whole, whichever is selected being an arbitrary matter of personal taste.

of focus of emphasis, a redistribution of tensions within the former act; and declare that unless the sound activity had been present to some extent in the prior coördination, it would be impossible for it now to come to prominence in consciousness. And such a reference would be only an amplification of what has already been said concerning the way in which the prior activity influences the value of the sound sensation. Or, we might point to cases of hypnotism, mono-ideaism and absent-mindedness, like that of Archimedes, as evidences that if the previous coördination is such as rigidly to lock the door, the auditory disturbance will knock in vain for admission to consciousness. Or, to speak more truly in the metaphor, the auditory activity must already have one foot over the threshold, if it is ever to gain admittance.

But it will be more satisfactory, probably, to refer to the biological side of the case, and point out that as the ear activity has been evolved on account of the advantage gained by the whole organism, it must stand in the strictest histological and physiological connection with the eye, or hand, or leg, or whatever other organ has been the overt center of action. It is absolutely impossible to think of the eye center as monopolizing consciousness and the ear apparatus as wholly quiescent. What happens is a certain relative prominence and subsidence as between the various organs which maintain the organic equilibrium.

Furthermore, the sound is not a mere stimulus, or mere sensation; it again is an act, that of hearing. The muscular response is involved in this as well as sensory stimulus; that is, there is a certain definite set of the motor apparatus involved in hearing just as much as there is in subsequent running away. The movement and posture of the head, the tension of the ear muscles, are required for the 'reception' of the sound. It is just as true to say that the sensation of sound arises from a motor response as that the running away is a response to the sound. This may be brought out by reference to the fact that Professor Baldwin, in the passage quoted, has inverted the real order as between his first and second elements. We do not have first a sound and then activity

of attention, unless sound is taken as mere nervous shock or physical event, not as conscious value. The conscious sensation of sound depends upon the motor response having already taken place; or, in terms of the previous statement (if stimulus is used as a conscious fact, and not as a mere physical event) it is the motor response or attention which constitutes that, which finally becomes the stimulus to another act. Once more, the final 'element,' the running away, is not merely motor, but is sensori-motor, having its sensory value and its muscular mechanism. It is also a coördination. And, finally, this sensori-motor coördination is not a new act, supervening upon what preceded. Just as the 'response' is necessary to constitute the stimulus, to determine it as sound and as this kind of sound, of wild beast or robber, so the sound experience must persist as a value in the running, to keep it up, to control it. The motor reaction involved in the running is, once more, into, not merely to, the sound. It occurs to change the sound, to get rid of it. The resulting quale, whatever it may be, has its meaning wholly determined by reference to the hearing of the sound. It is that experience mediated.¹ What we have is a circuit, not an arc or broken segment of a circle. This circuit is more truly termed organic than reflex, because the motor response determines the stimulus, just as truly as sensory stimulus determines movement. Indeed, the movement is only for the sake of determining the stimulus, of fixing what kind of a stimulus it is, of interpreting it.

I hope it will not appear that I am introducing needless refinements and distinctions into what, it may be urged, is after all an undoubted fact, that movement as response follows sensation as stimulus. It is not a question of making the account of the process more complicated, though it is always wise to be-

¹In other words, every reaction is of the same type as that which Professor Baldwin ascribes to imitation alone, viz., circular. Imitation is simply that particular form of the circuit in which the 'response' lends itself to comparatively unchanged maintainance of the prior experience. I say comparatively unchanged, for as far as this maintainance means additional control over the experience, it is being psychically changed, becoming more distinct. It is safe to suppose, moreover, that the 'repetition' is kept up only so long as this growth or mediation goes on. There is the new-in-the-old, if it is only the new sense of power.

ware of that false simplicity which is reached by leaving out of account a large part of the problem. It is a question of finding out what stimulus or sensation, what movement and response mean; a question of seeing that they mean distinctions of flexible function only, not of fixed existence; that one and the same occurrence plays either or both parts, according to the shift of interest; and that because of this functional distinction and relationship, the supposed problem of the adjustment of one to the other, whether by superior force in the stimulus or an agency *ad hoc* in the center or the soul, is a purely self-created problem.

We may see the disjointed character of the present theory, by calling to mind that it is impossible to apply the phrase 'sensori-motor' to the occurrence as a simple phrase of description; it has validity only as a term of interpretation, only, that is, as defining various functions exercised. In terms of description, the whole process may be sensory or it may be motor, but it cannot be sensori-motor. The 'stimulus,' the excitation of the nerve ending and of the sensory nerve, the central change, are just as much, or just as little, motion as the events taking place in the motor nerve and the muscles. It is one uninterrupted, continuous redistribution of mass in motion. And there is nothing in the process, from the standpoint of description, which entitles us to call this reflex. It is redistribution pure and simple; as much so as the burning of a log, or the falling of a house or the movement of the wind. In the physical process, as physical, there is nothing which can be set off as stimulus, nothing which reacts, nothing which is response. There is just a change in the system of tensions.

The same sort of thing is true when we describe the process purely from the psychical side. It is now all sensation, all sensory quale; the motion, as psychically described, is just as much sensation as is sound or light or burn. Take the withdrawing of the hand from the candle flame as example. What we have is a certain visual-heat-pain-muscular-quale, transformed into another visual-touch-muscular-quale—the flame now being visible only at a distance, or not at all, the touch sensation being altered, etc. If we symbolize the original visual quale by v ,

the temperature by h , the accompanying muscular sensation by m , the whole experience may be stated as $vhm-vhm-vhm'$; m being the quale of withdrawing, m' the sense of the status after the withdrawal. The motion is not a certain kind of existence; it is a sort of sensory experience interpreted, just as is candle flame, or burn from candle flame. All are on a par.

But, in spite of all this, it will be urged, there is a distinction between stimulus and response, between sensation and motion. Precisely; but we ought now to be in a condition to ask of what nature is the distinction, instead of taking it for granted as a distinction somehow lying in the existence of the facts themselves. We ought to be able to see that the ordinary conception of the reflex arc theory, instead of being a case of plain science, is a survival of the metaphysical dualism, first formulated by Plato, according to which the sensation is an ambiguous dweller on the border land of soul and body, the idea (or central process) is purely psychical, and the act (or movement) purely physical. Thus the reflex arc formulation is neither physical (or physiological) nor psychological; it is a mixed materialistic-spiritualistic assumption.

If the previous descriptive analysis has made obvious the need of a reconsideration of the reflex arc idea, of the nest of difficulties and assumptions in the apparently simple statement, it is now time to undertake an explanatory analysis. The fact is that stimulus and reponse are not distinctions of existence, but teleological distinctions, that is, distinctions of function, or part played, with reference to reaching or maintaining an end. With respect to this teleological process, two stages should be discriminated, as their confusion is one cause of the confusion attending the whole matter. In one case, the relation represents an organization of means with reference to a comprehensive end. It represents an accomplished adaptation. Such is the case in all well developed instincts, as when we say that the contact of eggs is a stimulus to the hen to set; or the sight of corn a stimulus to pick; such also is the case with all thoroughly formed habits, as when the contact with the floor stimulates walking. In these instances there is no question of consciousness of stimulus *as* stimulus, of response *as* response.

There is simply a continuously ordered sequence of acts, all adapted in themselves and in the order of their sequence, to reach a certain objective end, the reproduction of the species, the preservation of life, locomotion to a certain place. The end has got thoroughly organized into the means. In calling one stimulus, another response we mean nothing more than that such an orderly sequence of acts is taking place. The same sort of statement might be made equally well with reference to the succession of changes in a plant, so far as these are considered with reference to their adaptation to, say, producing seed. It is equally applicable to the series of events in the circulation of the blood, or the sequence of acts occurring in a self-binding reaper.¹

Regarding such cases of organization viewed as already attained, we may say, positively, that it is only the assumed common reference to an inclusive end which marks each member off as stimulus and response, that apart from such reference we have only antecedent and consequent;² in other words, the distinction is one of interpretation. Negatively, it must be pointed out that it is not legitimate to carry over, without change, exactly the same order of considerations to cases where it is a question of *conscious* stimulation and response. We may, in the above case, regard, if we please, stimulus and response each as an entire act, having an individuality of its own, subject even here to the qualification that individuality means not an entirely independent whole, but a division of labor as regards maintaining or reaching an end. But in any case, it is an act, a sensori-motor coöordination, which stimulates the response, itself in turn sensori-motor, not a sensation which stimulates a movement. Hence the illegitimacy of identifying, as is so often done, such cases of organized instincts or habits with the so-called reflex arc, or of transferring, without modification, considerations

¹To avoid misapprehension, I would say that I am not raising the question as to how far this teleology is real in any one of these cases; real or unreal, my point holds equally well. It is only when we regard the sequence of acts *as if* they were adapted to reach some end that it occurs to us to speak of one as stimulus and the other as response. Otherwise, we look at them as a *mere* series.

²Whether, even in such a determination, there is still not a reference of a more latent kind to an end is, of course, left open.

valid of this serial coördination of acts to the sensation-movement case.

The fallacy that arises when this is done is virtually the psychological or historical fallacy. A set of considerations which hold good only because of a completed process, is read into the content of the process which conditions this completed result. A state of things characterizing an outcome is regarded as a true description of the events which led up to this outcome; when, as a matter of fact, if this outcome had already been in existence, there would have been no necessity for the process. Or, to make the application to the case in hand, considerations valid of an attained organization or coördination, the orderly sequence of minor acts in a comprehensive coördination, are used to describe a process, viz., the distinction of mere sensation as stimulus and of mere movement as response, which takes place only because such an attained organization is no longer at hand, but is in process of constitution. Neither mere sensation, nor mere movement, can ever be either stimulus or response; only an act can be that; the *sensation* as stimulus means the lack of and search for such an objective stimulus, or orderly placing of an act; just as mere movement as response means the lack of and search for the right act to complete a given coördination.

A recurrence to our example will make these formulæ clearer. As long as the seeing is an unbroken act, which is as experienced no more mere sensation than it is mere motion (though the on-looker or psychological observer can interpret it into sensation and movement), it is in no sense the sensation which stimulates the reaching; we have, as already sufficiently indicated, only the serial steps in a coördination of *acts*. But now take a child who, upon reaching for bright light (that is, exercising the seeing-reaching coördination) has sometimes had a delightful exercise, sometimes found something good to eat and sometimes burned himself. *Now the response is not only uncertain, but the stimulus is equally uncertain; one is uncertain only in so far as the other is.* The real problem may be equally well stated as either to discover the right stimulus, to constitute the stimulus, or to discover, to constitute, the response. The question of whether to reach or to abstain from reaching is the question what

sort of a bright light have we here? Is it the one which means playing with one's hands, eating milk, or burning one's fingers? The stimulus must be constituted for the response to occur. Now it is at precisely this juncture and because of it that the distinction of sensation as stimulus and motion as response arises.

The sensation or conscious stimulus is not a thing or existence by itself; it is that phase of a coördination requiring attention because, by reason of the conflict within the coördination, it is uncertain how to complete it. It is to doubt as to the next act, whether to reach or no, which gives the motive to examining the act. The end to follow is, in this sense, the stimulus. It furnishes the motivation to attend to what has just taken place; to define it more carefully. From this point of view the discovery of the stimulus is the 'response' to possible movement as 'stimulus.' We must have an anticipatory sensation, an image, of the movements that may occur, together with their respective values, before attention will go to the seeing to break it up as a sensation of light, and of light of this particular kind. It is the initiated activities of reaching, which, inhibited by the conflict in the coördination, turn round, as it were, upon the seeing, and hold it from passing over into further act until its quality is determined. Just here the act as objective stimulus becomes transformed into sensation as possible, as conscious, stimulus. Just here also, motion as conscious response emerges.

In other words, sensation as stimulus does not mean any particular psychical *existence*. It means simply a function, and will have its value shift according to the special work requiring to be done. At one moment the various activities of reaching and withdrawing will be the sensation, because they are that phase of activity which sets the problem, or creates the demand for, the next act. At the next moment the previous act of seeing will furnish the sensation, being, in turn, that phase of activity which sets the pace upon which depends further action. Generalized, sensation as stimulus, is always that phase of activity requiring to be defined in order that a coördination may be completed. What the sensation will be in particular at a given time, therefore, will depend entirely upon the way in which an activity is being used. It has no fixed quality of its

own. The search for the stimulus is the search for exact conditions of action; that is, for the state of things which decides how a beginning coördination should be completed.

Similarly, motion, as response, has only a functional value. It is whatever will serve to complete the disintegrating coördination. Just as the discovery of the sensation marks the establishing of the problem, so the constitution of the response marks the solution of this problem. At one time, fixing attention, holding the eye fixed, upon the seeing and thus bringing out a certain quale of light is the response, because that is the particular act called for just then; at another time, the movement of the arm away from the light is the response. There is nothing in itself which may be labelled response. That one certain set of sensory quales should be marked off by themselves as 'motion' and put in antithesis to such sensory quales as those of color, sound and contact, as legitimate claimants to the title of sensation, is wholly inexplicable unless we keep the difference of function in view. It is the eye and ear sensations which fix for us the problem; which report to us the conditions which have to be met if the coördination is to be successfully completed; and just the moment we need to know about our movements to get an adequate report, just that moment, motion miraculously (from the ordinary standpoint) ceases to be motion and become 'muscular sensation.' On the other hand, take the change in values of experience, the transformation of sensory quales. Whether this change will or will not be interpreted as movement, whether or not any consciousness of movement will arise, will depend upon whether this change is satisfactory, whether or not it is regarded as a harmonious development of a coördination, or whether the change is regarded as simply a means in solving a problem, an instrument in reaching a more satisfactory coördination. So long as our experience runs smoothly we are no more conscious of motion as motion than we are of this or that color or sound by itself.

To sum up: the distinction of sensation and movement as stimulus and response respectively is not a distinction which can be regarded as descriptive of anything which holds of psychical events or existences as such. The only events to which the terms stimulus and response can be descriptively applied are to

minor acts serving by their respective positions to the maintenance of some organized coördination. The conscious stimulus or sensation, and the conscious response or motion, have a special genesis or motivation, and a special end or function. The reflex arc theory, by neglecting, by abstracting from, this genesis and this function gives us one disjointed part of a process as if it were the whole. It gives us literally an arc, instead of the circuit; and not giving us the circuit of which it is an arc, does not enable us to place, to center, the arc. This arc, again, falls apart into two separate existences having to be either mechanically or externally adjusted to each other.

✓ The circle is a coördination, some of whose members have come into conflict with each other. It is the temporary disintegration and need of reconstitution which occasions, which affords the genesis of, the conscious distinction into sensory stimulus on one side and motor response on the other. The stimulus is that phase of the forming coördination which represents the conditions which have to be met in bringing it to a successful issue; the response is that phase of one and the same forming coördination which gives the key to meeting these conditions, which serves as instrument in effecting the successful coördination. They are therefore strictly correlative and contemporaneous. The stimulus is something to be discovered; to be made out; if the activity affords its own adequate stimulation, there is no stimulus save in the objective sense already referred to. As soon as it is adequately determined, then and then only is the response also complete. To attain either, means that the coördination has completed itself. Moreover, it is the motor response which assists in discovering and constituting the stimulus. It is the holding of the movement at a certain stage which creates the sensation, which throws it into relief.

It is the coördination which unifies that which the reflex arc concept gives us only in disjointed fragments. It is the circuit within which fall distinctions of stimulus and response as functional phases of its own mediation or completion. The point of this story is in its application; but the application of it to the question of the nature of psychical evolution, to the distinction between sensational and rational consciousness, and the nature of judgment must be deferred to a more favorable opportunity.